Hydrogen Transportation and Distribution as an Energy Carrier

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Workshop do Evento de Apresentação do
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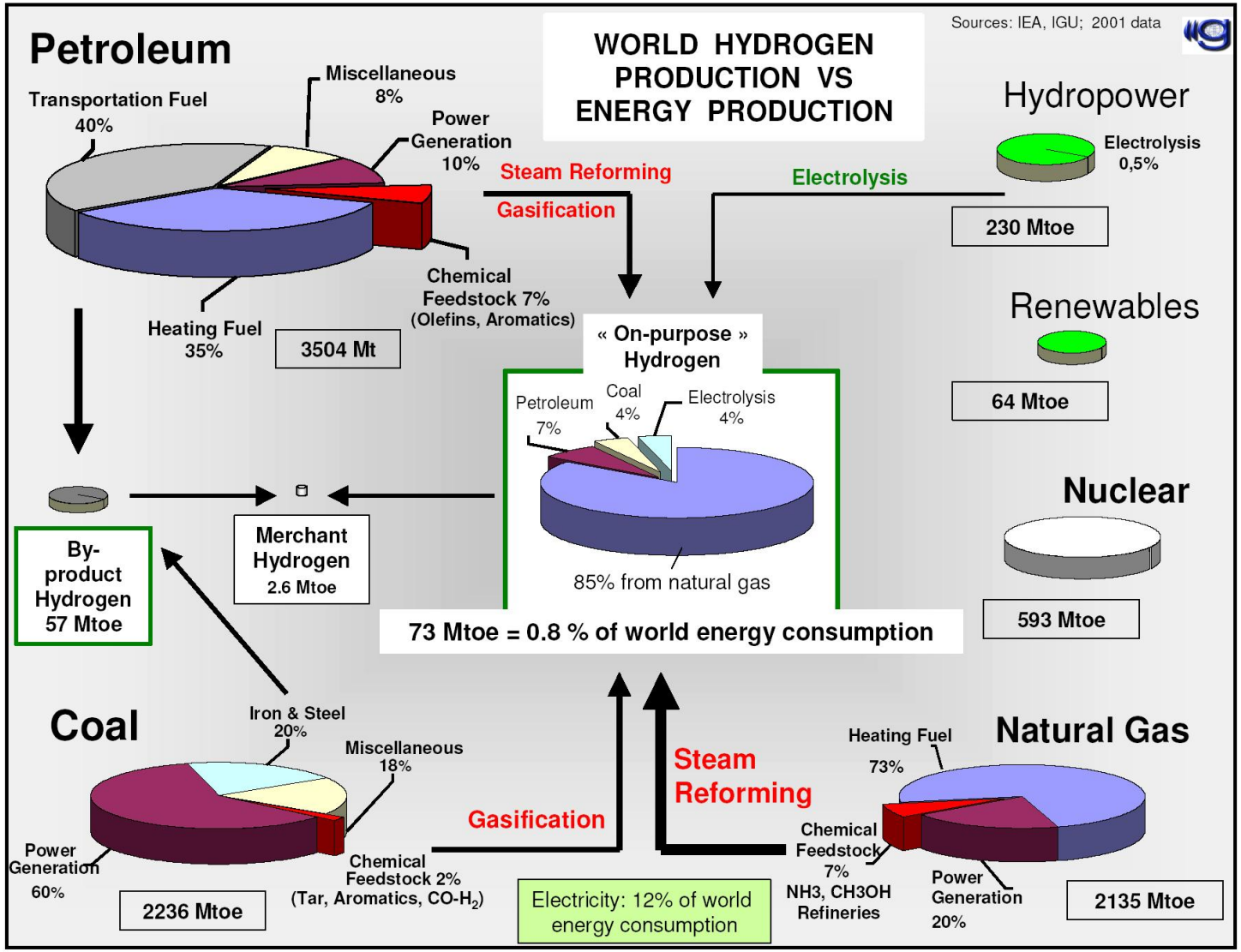
Outline

- Petrobras Vision of Hydrogen Infrastructure for the near and long term
- Hydrogen Refueling Stations Demonstrations Facilities
  - ✓ Hydrogen Fuel Cell Buses For Urban Transport In Brazil Project (São Paulo)
  - ✓ Brazilian Hybrid Bus with Fuel Cell and Battery Project (Rio de Janeiro)



Ref.: J. SaintJust (Hyradix), Hydrogen from Natural Gas as Energy Carrier, EHEC, 2003

Hydrogen Production: Costs

Hydrogen Source	Hydrogen Cost, USD/GJ
Coal / gas / oil	1-5
NG, without emissions of CO_2	8-10
Coal, without emissions of CO_2	10-13
Biomass	12-18
Nuclear (electricity)	15-20
Wind, onshore	15-25
Wind, offshore	20-30
Thermal solar and solar PV	25-50

Ref.: J. SaintJust (Hyradix), Hydrogen from Natural Gas as Energy Carrier, EHEC, 2003 / The Economist / IEA

Future Hydrogen Supply Costs
$/GJ, 2020

Gasoline/diesel	*6-8*
Natural gas	*3-5*
H2 from natural gas with CCS	7-11
H2 from coal with CCS	8-11
H2 from biomass (gasification)	10-18
H2 from onshore wind	17-23
H2 from offshore wind	22-30
H2 from thermal solar electricity	27-35
H2 from solar PV	47-75
H2 from nuclear	15-20
H2 from HTGR cogeneration	10-25

Source: IEA

Pathway to Sustainability

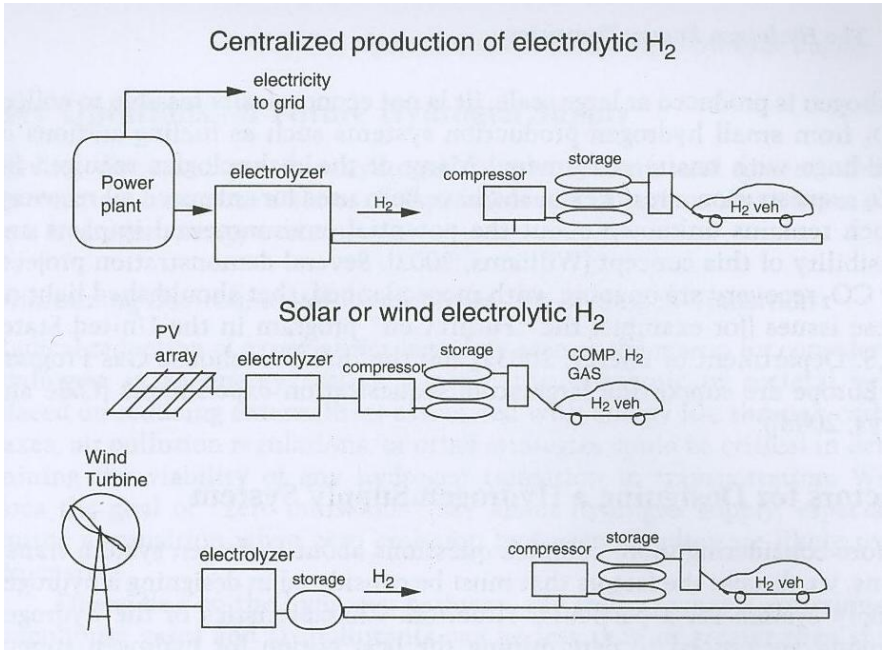
Oil

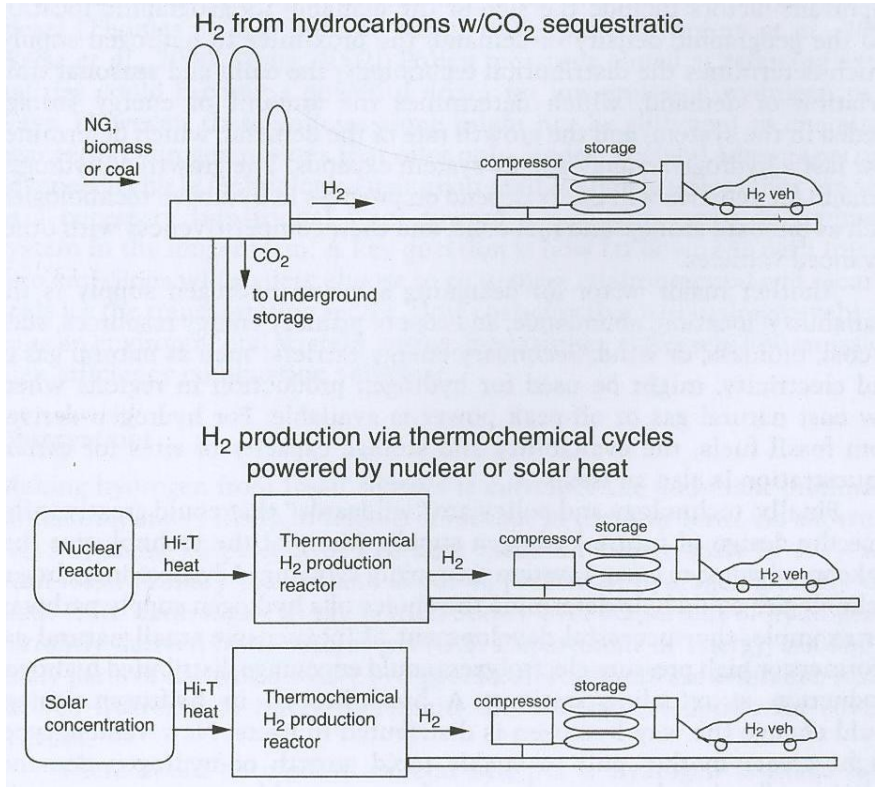
Natural Gas

Biofuels

Renewable souces and Hydrogen

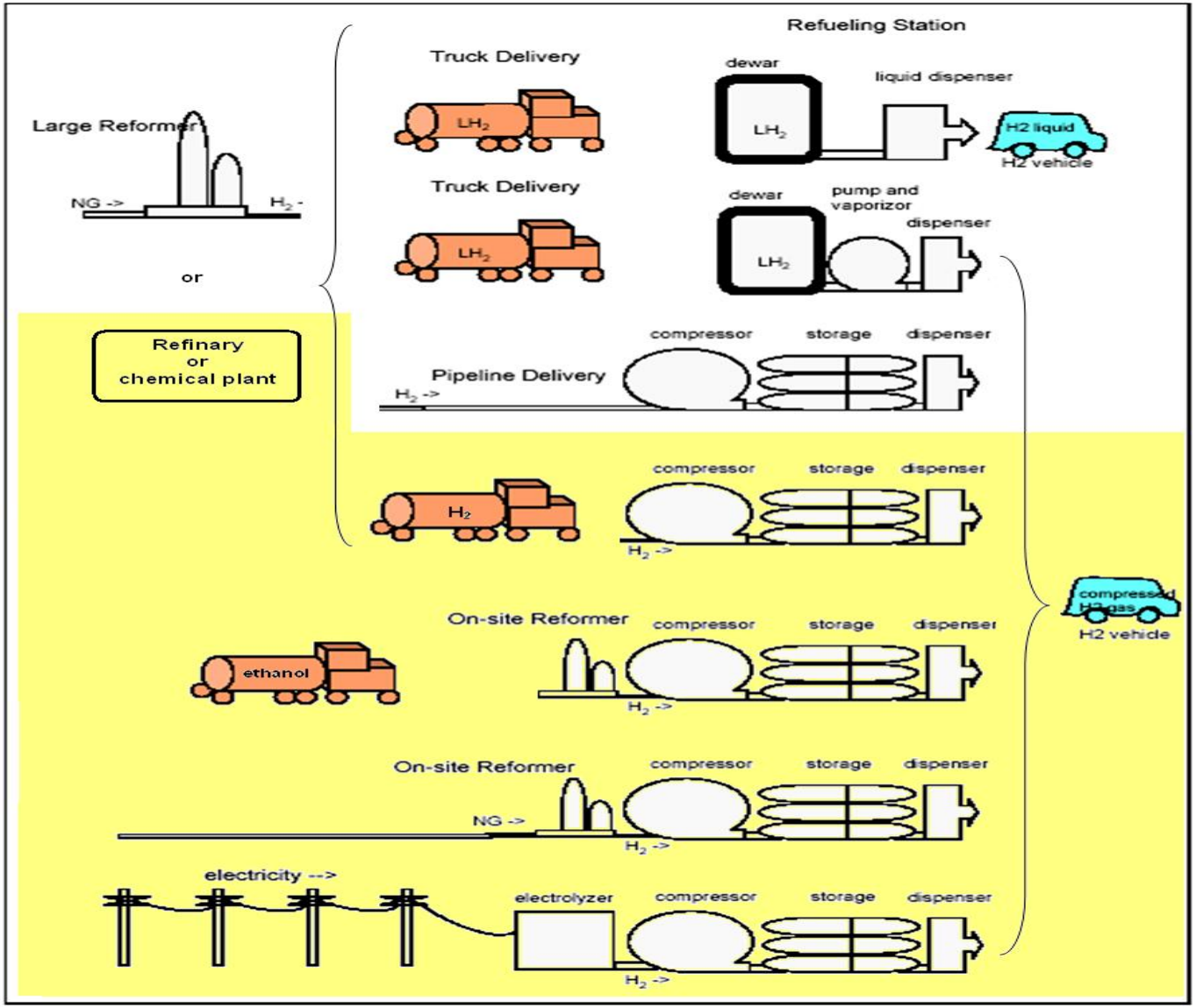
Alternatives for Hydrogen Refueling Station long term





Source: Joan Ogden

Alternatives for Hydrogen Refueling Station in Brazil - near term



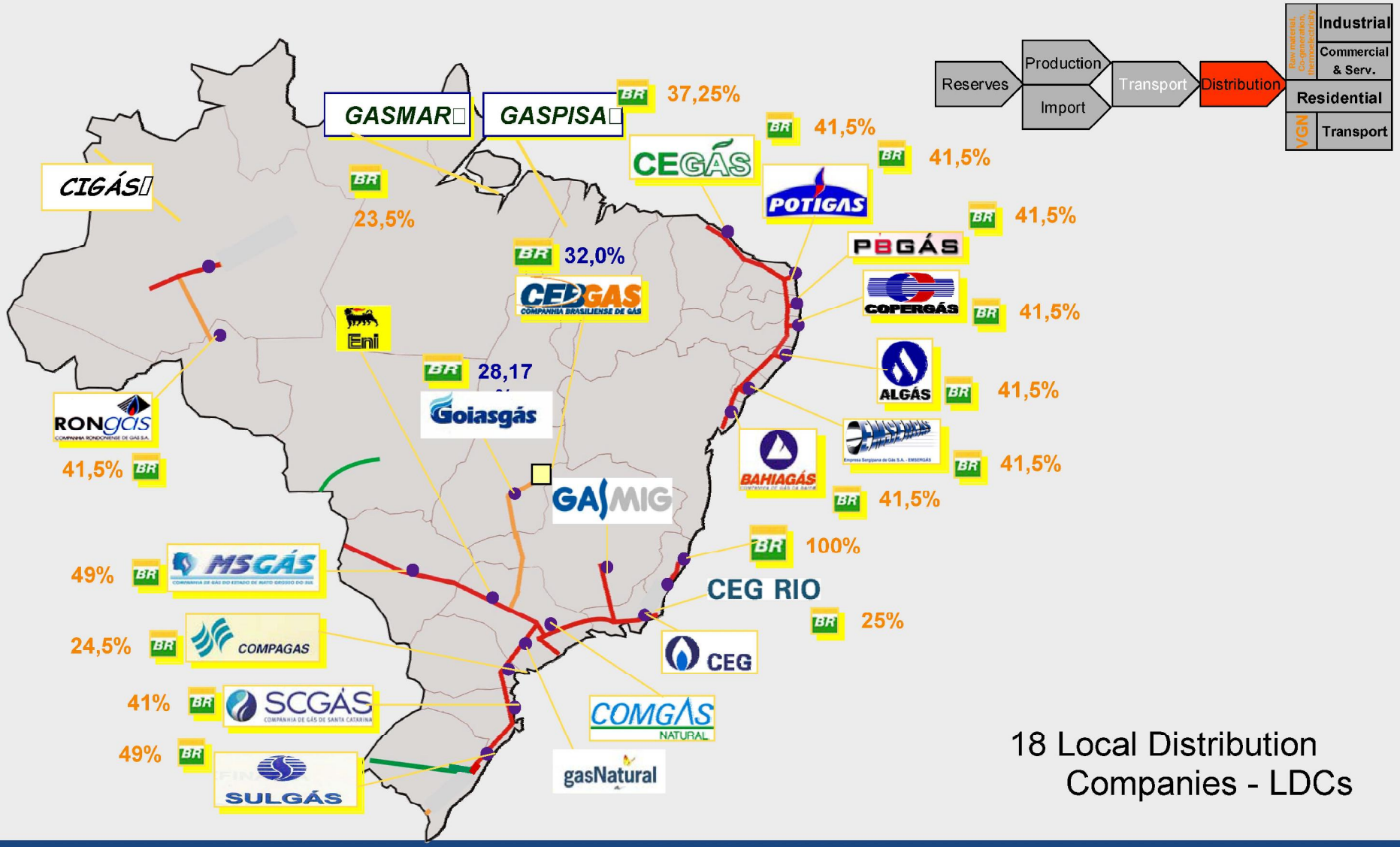
Ref.: Adapteded from Schoenung, S.M., A comparison of hydrogen vehicle and refueling infrastructure alternatives: an analysis developed for the International Energy Agency, 14th WHEC, Canadá, 2002

Total Hydrogen Generation Capacity at Petrobras's Refinarys Nowadays (Nm³/day)

Total Hydrogen Generation Capacity at Petrobras's Refinarys in 2008:

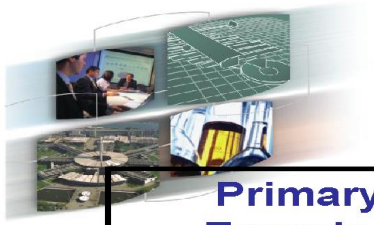
10.097.000 Nm³/day

Petrobras Participation in Natural Gas Distribution Companies in Brazil



Hydrogen Generation Increase at Petrobras's Refinarys by 2013 (Nm³/day)

U N	Capacidade (Nm³/dia)	Fase Atual	Empreendimento
REVAP	1.200.000	Execução	Diesel
REPAR	1.600.000	Execução	Diesel
RLAM	260.000	Execução	Gasolina
RLAM	1.100.000	Proj Básico	Diesel
RECAP	550.000	Proj Básico	Diesel
REDUC	750.000	Avaliação do Negocio	Diesel
REDUC	1.600.000	Proj Conceitual	HCC
REFAP	1.160.000	Proj Conceitual	Diesel
REGAP	300.000	Execução	Gasolina
REGAP	1.100.000	Proj Conceitual	Diesel
REPLAN	1.800.000	Proj Conceitual	Diesel
RPBC	2.000.000	Avaliação do Negocio	Diesel (Modern)
RNEST	2 x 3.000.000	Proj Básico	
COMPERJ	2 x 2.800.000	Proj Básico	
PREMIUN	6 x 3.000.000	Proj Conceitual	
total	**43.020.000**		



Primary Energies	Past and Present Carriers	Additional Future Carriers
Oil	Self, refined cuts	
Natural Gas	Self, LNG, electricity	GTL, H2
Coal	Electricity, town Gas	H2, Diesel (China)
Nuclear	Electricity	H2
Hydro	Electricity	H2
Biomass	Ethanol, diester, electricity	H2
Wind	Electricity	H2
Solar	Electricity	H2
Geothermal	Electricity	H2

Ref.: J. SaintJust (Hyradix), Hydrogen from Natural Gas as Energy Carrier, EHEC, 2003

Iniciatives of Petrobras in Hydrogen Infrastructure

❑ Main Projects

- Assessment of blend H_2+NG (HCNG)
- Refuelling Station (pure H_2) to hydrogen Bus Project in São Paulo
- Refuelling Station (HCNG) to general use in Rio de Janeiro

CONSORTIUM FOR THE IMPLEMENTATION OF THE PROJECT "HYDROGEN FUEL CELL BUSES FOR URBAN TRANSPORT IN BRAZIL"

- Braziliam Fuel Cell Bus Broject (São Paulo)
  - Financiado pela Global Environment Facility (GEF) and MME Brasil
  - Implementation Agency: United Nations Development Programme (UNDP)

- Refuelling Station Caracteristics
  - H2 production: 120Kg/day
  - Energy Consuption: 4.8 kWh/Nm3
  - H2 purity: 99.95% (from electrolizer)
  - Stoarage: 144kg @ 414 bar

Ministry of Mines and Energy

BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

GEF

PNUD

EMTU

FINEP FINANCIADORA DE ESTUDOS E PROJETOS

BALLARD

EPRI ELECTRIC POWER RESEARCH INSTITUTE

HYDROGENICS CORPORATION

Marcopolo

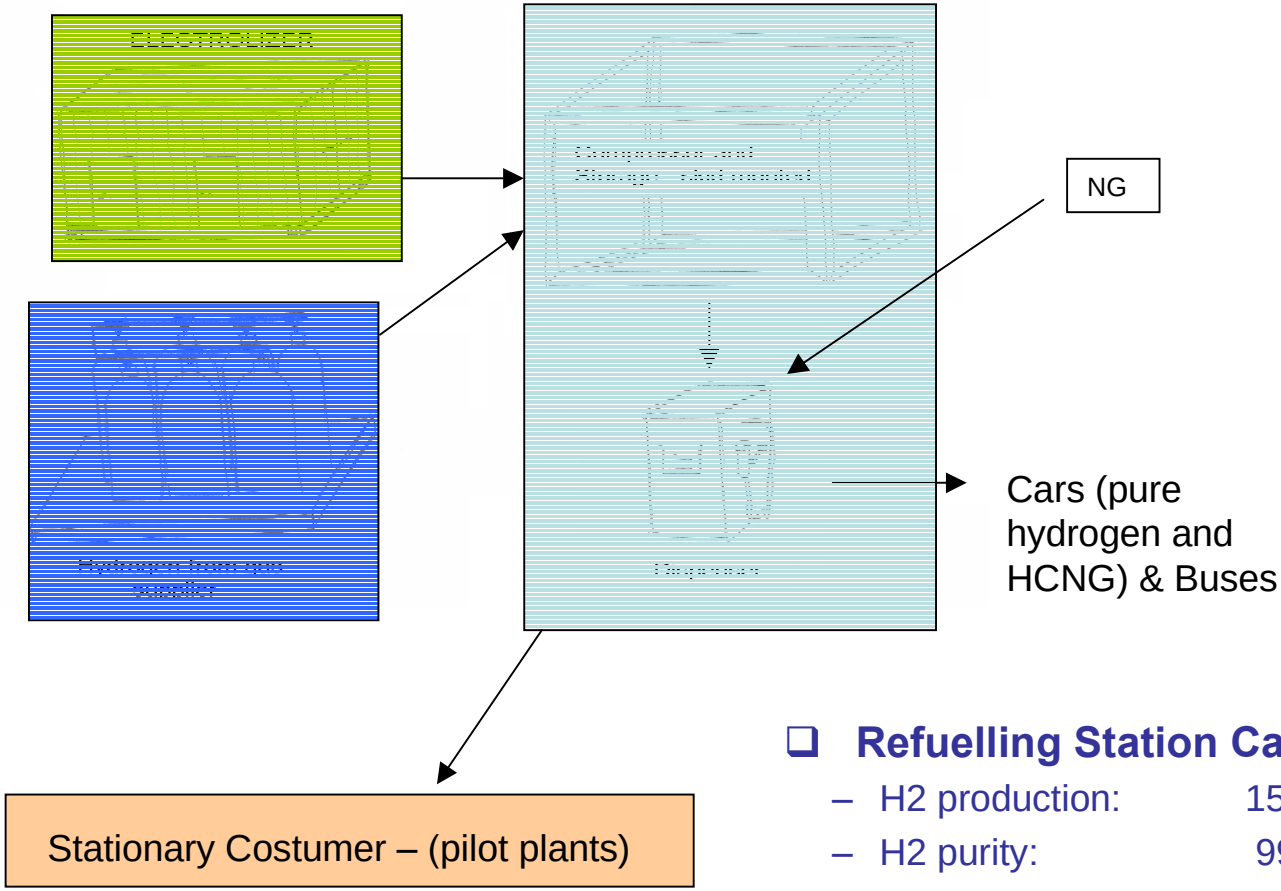
NUCELLSYS THE FUEL CELL SYSTEM COMPANY

BR PETROBRAS

tuttotrasporti

"Brazilian Hybrid Bus with Fuel Cell and Battery "

- Brazilian Hybrid Bus with Fuel Cell and Battery Project
  - Design by LabH2-Inovation - COPPE
  - Funding by FINEP and Petrobras
  - Partnerships: Petrobras, UFRJ/COPPE, Busscar, WEG, Rotarex, Solution and Others



- **Refuelling Station Caracteristics**
  - H2 production: 15Nm^3/hour
  - H2 purity: 99.95% (from electrolizer)
  - HCNG: HCNG (by 50%NG)

OBRIGADO!

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